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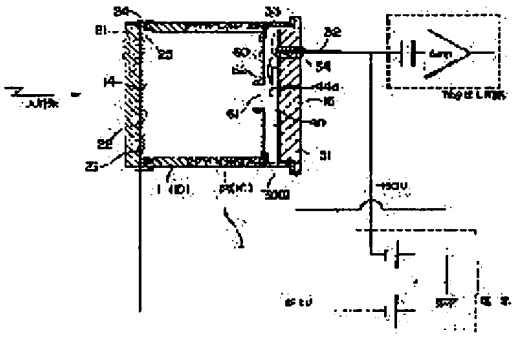
(54) ELECTRON TUBE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an electron tube capable of a stable operation over a long period of time.
SOLUTION: In this electron tube, an opening area of an opening 61 of an anode electrode 60 is formed smaller than an incident area of an electron incident face 44a of a semiconductor device 40, the semiconductor device 40 is constituted so as to have an electron incident face 44a whose conductor type is (p) type and a board 41 whose conductor type is (n) type, electrically connect an (n) type board 41 to a system 31, have the anode electrode 60 and the system 31 with their same potential, and apply a reverse-bias to the semiconductor device 40.



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CLAIMS

[Claim(s)]
[Claim 1] The case which consists of an insulating ingredient while having the 1st opening, said 1st opening, and the 2nd opening located in the opposite side, An input face-plate with the photoelectric surface which is established in a 1st [of said case / said] opening side, and emits an electron corresponding to the light by which incidence was carried out, The stem which is prepared in a 2nd [of said case / said] opening side, and consists of a conductive ingredient, The semiconductor device which has the electronic plane of incidence by which the electron which was located in the vacuum side of said stem and was emitted from said photoelectric surface is irradiated, In the electron tube equipped with the anode electrode with opening which was located near said semiconductor device between said semiconductor devices and said photoelectric surfaces, and was confronted with said semiconductor device The opening area of said opening of said anode electrode It is formed smaller than the plane-of-incidence product of said electronic plane of incidence of said semiconductor device. Said semiconductor device The electron tube with which a conductivity type is characterized by connecting said said n type of substrate to said stem electrically, making said anode electrode and said stem this potential while said electronic plane of incidence and conductivity type of p mold have the substrate of n mold, and impressing a reverse bias to said semiconductor device.
[Claim 2] The electron tube according to claim 1 characterized by making said opening of said anode electrode, and the collimator section of the shape of a cylinder arranged in the said alignment turn and protrude on said photoelectric surface in said anode electrode.
[Claim 3] The electron tube according to claim 1 characterized by having arranged the conductive mesh electrode to said opening circles of said anode electrode.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is used as a photodetector for measuring a feeble light quantitatively, and relates to the electron tube with the semiconductor device which carries out multiplication of the electron especially emitted from the photoelectric surface, and outputs it.
[0002]
[Description of the Prior Art] Conventionally, after accelerating and converging the electron emitted by the incidence of light from the photoelectric surface with an electron lens, the electron tube which carries out incidence to a semiconductor device and acquires high gain is known. This electron tube is indicated by for example, JP,5-54849,A, JP,6-318447,A, JP,7-320681,A, US No. 5475227 official report, etc. Especially, the gas molecule which stuck to the electronic plane of incidence of a semiconductor device with the electron which carries out incidence to a semiconductor device serves as ion, it is accelerated towards the photoelectric surface, this feeds back, and the structure for preventing this is indicated by US No. 5475227 official report to the phenomenon of degrading the photoelectric surface remarkably. A semicircle tubed ion deflecting electrode is arranged just before a semiconductor device, and the orbit of the ion generated on the electronic plane of incidence of a semiconductor device is bent, and, specifically, it is considering as the configuration from which ion does not return to the photoelectric surface.
[0003]
[Problem(s) to be Solved by the Invention] However, in invention indicated by the above-mentioned US No. 5475227 official report, since the ion generated from the semiconductor device was not fed back to the photoelectric surface by the orbit being bent, although degradation of the photoelectric surface could be prevented, there was a problem that the bent ion collided with an insulating side attachment wall, and stable actuation was not obtained. It is because the orbit of the electron which secondary electron emits from an insulating side attachment wall, and a side attachment wall is just charged, and goes to a semiconductor device from the photoelectric surface by **** of ion as the reason is affected. Especially, with the configuration of the conventional example, since only the specific part of a side attachment wall is charged by the collision of ion, an electron lens becomes remarkably unsymmetrical and an electronic orbit is bent greatly. Moreover, the secondary electron generated by the collision of ion carried out incidence to the semiconductor device, the false signal was generated and there was a problem which it strays [problem] and produces new instability.
[0004] This invention was made in order to solve an above-mentioned technical problem, and it aims at offering the electron tube which enables actuation continued and stabilized especially at the long period of time.
[0005]
[Means for Solving the Problem] The case which consists of an insulating ingredient while the electron tube by this invention has the 1st opening, the 1st opening, and the 2nd opening located in the opposite side, An input face-plate with the photoelectric surface which is established in a 1st [of a case] opening side and emits an electron corresponding to the light by which incidence was carried out, It is located in the vacuum side of the stem which is prepared in a 2nd [of a case] opening side and consists of a conductive ingredient, and a stem. In the electron tube equipped with the anode electrode with opening which was located near the semiconductor device between the semiconductor device which has the electronic plane of incidence by which the electron emitted from the photoelectric surface is irradiated, and a semiconductor device and the photoelectric surface, and was confronted with the semiconductor device The opening area of opening of an anode electrode is formed smaller than the plane-of-incidence product of the electronic plane of incidence of

a semiconductor device. A semiconductor device A conductivity type is characterized by connecting the substrate of n mold to a stem electrically, making an anode electrode and a stem this potential, while the electronic plane of incidence and the conductivity type of p mold have the substrate of n mold, and impressing a reverse bias to a semiconductor device.

[0006] In this electron tube, after the light which carried out incidence to the input face-plate from the exterior is changed into an electron by the photoelectric surface and passes opening of an anode electrode according to it, it reaches the electronic plane of incidence of a semiconductor device. At this time, a cation is generated in electronic plane of incidence. And since an anode electrode serves as forward potential to the electronic plane of incidence of a semiconductor device and it becomes a reverse bias for the cation generated in electronic plane of incidence, the generated cation cannot pass along opening of an anode electrode, and can return to neither the photoelectric surface nor a case.

[0007] In this case, in an anode electrode, when opening of an anode electrode and the collimator section of the shape of a cylinder arranged in the said alignment are made to turn and protrude on the photoelectric surface, it is desirable. In using a semiconductor device (for example, APD), by preparing the collimator section in an anode electrode, invasion of the electric field which go to a semiconductor device exceeding opening of an anode electrode from the photoelectric surface can be suppressed to the minimum, and ion feedback can be controlled very effectively.

[0008] Moreover, it is desirable when a conductive mesh electrode is arranged to the opening circles of an anode electrode. In using a semiconductor device (for example, PD), by preparing a mesh electrode in an anode electrode, invasion of the electric field which go to a semiconductor device exceeding opening of an anode electrode from the photoelectric surface can be suppressed to the minimum, and ion feedback can be controlled very effectively.

[0009]

[Embodiment of the Invention] Hereafter, the suitable operation gestalt of the electron tube by this invention is explained to a detail with a drawing.

[0010] Drawing 1 is the sectional view showing the 1st operation gestalt of the electron tube concerning this invention. As shown in this drawing, the electron tube 1 has the case 10 of the shape of a cylinder which consists of an insulating ingredient, and consists of the bell shape cathode electrode 11 made from covar and the ceramic section 12 which the bore and the appearance compared this case 10 of each other both equally, and were made to fix, and a welding flange 13 fixed to the ceramic section 12 while having the concentric circle configuration to both. And as for the cathode electrode 11, the ceramic section 12, and the welding flange 13, unification is attained by soldering. In addition, when the electron lens mentioned later is taken into consideration and a case 10 has the outer diameter of 15mm, the bore of 12mm, and a dimension with an overall length of 13mm, 5mm is suitable for the die length of the cathode electrode 11.

[0011] The glass input face-plate 21 which makes light penetrate is fixed to the cathode electrode 11 of a case 10, and this input face-plate 21 is arranged at the 1st opening 14 side formed in the 1 side of a case 10 while it has the photoelectric surface 22 inside. And this input face-plate 21 is united with the cathode electrode 11 through in JUMU 23 after producing the photoelectric surface 22. The photoelectric-surface electrode 25 which consists of a thin film of chromium is arranged so that the photoelectric surface 22 and in JUMU 23 may be electrically connected to the circumference part of the photoelectric surface 22. And the bore of 8mm of the photoelectric-surface electrode 25 has specified the effective diameter of the photoelectric surface 22. Moreover, in JUMU 23 is formed so that it may project by the medial surface of the bell shape base material 24. And by arranging in order of in JUMU 23 and the input face-plate 21, and pushing the cathode electrode 11 and the input face-plate 21 of each other on the cathode electrode 11, in JUMU 23 deforms, it functions as adhesives, and the input face-plate 21 is united with a case 10.

[0012] The disc-like stem 31 which consists of a conductive ingredient (for example, covar metal) is fixed to the welding flange 13 of a case 10, and this stem 31 is arranged at the 2nd opening 15 side formed in the side besides a case 10. The penetration pin 32 insulated with glass 34 is fixed to this stem 31, the resistance welding of the stem 31 is carried out to the welding flange 13 in that circumference part, and it is united with the case 10. Therefore, it is unified by the case 10, the input face-plate 21, and the stem 31, and the electron tube 1 holds the vacuum airtight.

[0013] As shown in drawing 2 , on the field by the side of the vacuum in a stem 31, the semiconductor device 40 which operates as APD (avalanche photo-diode) has fixed through the conductive adhesives 50. A semiconductor device 40 uses the high concentration silicon substrate 41 of n mold as a substrate ingredient, and the carrier multiplication layer 42 of p mold is formed in the central part by disc-like. The guard ring layer 43 which consists of a high concentration n type layer by the same thickness as the carrier

multiplication layer 42 is formed in the periphery of this carrier multiplication layer 42. The breakdown voltage control layer 44 which consists of a high concentration p type layer is formed in the front face of the carrier multiplication layer 42. The front face of this breakdown voltage control layer 44 is formed as electronic plane-of-incidence 44a, and an oxide film 45 and ****** 46 are formed so that it may build over the circumference part and the guard ring layer 43 of the breakdown voltage control layer 44. In order to supply anode potential to the breakdown voltage control layer 44, the plane-of-incidence electrode 47 which vapor-deposited aluminum in the shape of a circular ring, and was formed is formed in the outermost side of a semiconductor device 40. Furthermore, the guard ring layer 43 and the flowing circumference electrode 48 are formed in the outermost side of a semiconductor device 40, and it is made to estrange this circumference electrode 48 with predetermined spacing to the plane-of-incidence electrode 47. In addition, 3mm is suitable for the diameter of electronic plane-of-incidence 44a among the plane-of-incidence electrodes 47 at a way.

[0014] The high concentration n mold silicon substrate 41 of this semiconductor device 40 fixes to a stem 31 through electroconductive glue 50, it is using this electroconductive glue 50, and a stem 31 and the high concentration n mold substrate 41 flow through it electrically. Moreover, the plane-of-incidence electrode 47 of a semiconductor device 40 is connected by the wire 33 to the penetration pin 32 insulated with the stem 31.

[0015] As shown in drawing 1 and drawing 2 , the tabular anode electrode 60 is arranged between a semiconductor device 40 and the photoelectric surface 22, and this anode electrode 60 is located in the side near a semiconductor device 40 while being fixed to the welding flange 13. In addition, 1mm is suitable for spacing of the anode electrode 60 and a semiconductor device 40. The opening 61 confronted with electronic plane-of-incidence 44a of a semiconductor device 40 is formed in the center of this anode electrode 60, the collimator section (collimator electrode) 62 of the shape of a cylinder projected to the anode electrode 60 so that opening 61 might be surrounded is formed in one, and this collimator section 62 is arranged in the said alignment to opening 61 while projecting towards the photoelectric surface 22. Moreover, the diameter of this opening 61 is 2mm, and the height of the bore of the collimator section 62 is 1mm in 2mm.

[0016] Having made the diameter (2mm) of the opening 61 of the anode electrode 60 smaller than the diameter (3mm) of electronic plane-of-incidence 44a here It is for preventing an electron carrying out incidence to the unnecessary part of a semiconductor device 40, i.e., the circumference part of electronic plane-of-incidence 44a, and electrifying an oxide film 45 and a nitride 46, or giving a damage to a pn junction interface and the contact surface of a semi-conductor (44) and a metal electrode (47), and degrading a component property. Moreover, adding the collimator section 62 to the anode electrode 60 suppresses penetration of the electric field which go to a semiconductor device 40 exceeding opening 61 from the photoelectric surface 22 to the minimum, and it is for raising the effectiveness which controls the ion feedback which mentions later. Furthermore, the collimator section 62 has the work which returns perpendicularly the direction of the electron which is going to emit from the circumference part of the photoelectric surface 22, and is going to carry out incidence to a semiconductor device 40 aslant. If an electron carries out incidence to a semiconductor device 40 aslant, in order to cross the dead layer (a part for the management of the breakdown voltage control layer 44) of a semiconductor device 40 in a longer stroke, the rate that an incidence electron reaches to a depletion layer decreases, and multiplication gain becomes small. Then, dispersion depending on the electron emission location of multiplication gain is controlled by adding the collimator section 62 and correcting an electronic orbit. In addition, the anode electrode 60 presses and forms a stainless plate with a thickness of 0.3mm. Moreover, the anode electrode 60 may be formed by the welding flange 13 and one.

[0017] Next, the assembly of the electron tube 1 of a configuration of having mentioned above is explained. First, die bond of the semiconductor device 40 is carried out to a stem 31, then the plane-of-incidence electrode 47 and the penetration pin 32 are connected with a wire 33. On the other hand, the anode electrode 60 is fixed to the welding flange 13 of a case 10 in resistance welding, and it is made to fix the welding flange 13 and a stem 31 in resistance welding. And the case 10 which unified the input face-plate 21, IJUMU 23, and a stem 31 is put into the vacuum devices called transfer equipment in the condition of having made it another object, and after stating for about 10 hours and giving 300 degrees C of one king, the photoelectric surface 22 is produced in one side of the input face-plate 21. Then, it is unified in a vacuum through in JUMU 23, and the input face-plate 21 and a case 10 change the electron tube 1 into a vacuum airtight condition. Finally, the vacuum of transfer equipment is leaked and a series of strokes are ended.

[0018] As shown in drawing 1 , -12kV is impressed to the photoelectric surface 22 and the cathode electrode 11 of the electron tube 1, and the anode electrode 60 is grounded and impresses OV. At this time, the

cathode electrode 11 and the anode electrode 60 form an electron lens, it reduces to the diameter of 1.5mm smaller than the bore of the collimator section 62, and the electron emitted from the photoelectric surface 22 with an effective diameter of 8mm is introduced into electronic plane-of-incidence 44a of a semiconductor device 40. On the other hand, -150V are impressed to the breakdown voltage control layer (anode) 44 of a semiconductor device 40, a silicon substrate 41 (cathode) is grounded and OV is impressed so that a reverse bias may be impressed to a semiconductor device 40 at pn junction. Therefore, about 50 times as many avalanche multiplication gain as this is acquired by APD.

[0019] Then, if light carries out incidence to the electron tube 1, an electron is emitted into a vacuum from the photoelectric surface 22, and it will converge, while being accelerated with an electron lens, and this electron will have the energy of l2kev, and it will carry out incidence to electronic plane-of-incidence 44a of APD40. Since this electron increases further 50 times by the avalanche multiplication which increases about 3000 times in this first multiplication process, and continues since the electronic-electron hole pair per piece is generated whenever it loses 3.6eV of energy within APD40, it is total and serves as gain of about 2x105.

[0020] Since the multiplication factor of the first rank is as high as 3000 figures triple [about] compared with the photomultiplier tube (henceforth "PMT") usual in this electron tube 1, very good detection of S/N is possible. When actually very feeble pulsed light carried out incidence and an average of 4 electronic extent was emitted from the photoelectric surface 22, in conventional PMT, it could discriminate from the number of input photoelectrons (the number of incident light children) from which it was not able to discriminate. In case such a property acquired with the electron tube 1 mentioned above observes quantitatively the fluorescence emitted from the living body minute amount matter, it is very effective. And it is very important that electron tube 1 the very thing operates to stability over a long period of time.

[0021] In the electron tube 1 in this operation gestalt, -150V are impressed to electronic plane-of-incidence 44a of a semiconductor device 40 from the power source through the penetration pin 32, the wire 33, and the plane-of-incidence electrode 47. On the other hand, OV is impressed to the anode electrode 60 through the welding flange 13. That is, the anode electrode 60 serves as forward potential to the electronic plane of incidence 44 of a semiconductor device 40. Since this becomes a reverse bias for the cation generated in electronic plane-of-incidence 44a, the generated cation cannot pass along the opening 61 of the anode electrode 60, and can return to neither the photoelectric surface 20 nor a case 10.

[0022] That is, in the electron tube 1 mentioned above, since the anode electrode 60 is maintained at reverse potential to forward potential, i.e., the cation generated in electronic plane-of-incidence 44a, to electronic plane-of-incidence 44a, such a cation generated in electronic plane-of-incidence 44a cannot return to the insulating part of the photoelectric surface 22 or a case 10 over the anode electrode 60. Therefore, since the photoelectric surface 22 of the electron tube 1 is not influenced by such ion of feedback, it does not deteriorate to actuation of long duration. Furthermore, without electrifying a case 10, since it does not return to the insulating part of a case 10, either, a cation does not affect the orbit of the electron which emits from the photoelectric surface 22 and results in a semiconductor device 40, or emits secondary electron from a case 10, and does not generate a false signal. Therefore, in the electron tube 1, actuation stabilized very much over the long period of time is realized.

[0023] In addition, supposing the ion generated in electronic plane-of-incidence 44a of a semiconductor device 40 returns to the photoelectric surface 22, since a cation returns to the photoelectric surface 22 with high energy called about 12 keV(s) according to the potential difference of the photoelectric surface 22 and electronic plane-of-incidence 44a, the spatter of the component of the photoelectric surface 22 will be carried out with a cation. Therefore, in the situation that the ion generated in electronic plane-of-incidence 44a returns to the photoelectric surface 22, photoelectric-surface sensibility will deteriorate remarkably in short-time actuation.

[0024] Next, the 2nd operation gestalt of the electron tube 100 built over this invention based on drawing 3 - drawing 6 is explained. In addition, hereafter, while explaining difference with the 1st operation gestalt, in a drawing, the same sign is attached about a same or equivalent component.

[0025] As shown in drawing 3 , the cathode electrode 18 is as short as about 2mm, and the middle flanges 15a and 15b are inserted in two places in the middle of the insulating case 90. Moreover, large PD of an electronic plane-of-incidence product was used as a semiconductor device 80, the opening 71 with a large area was formed in the anode electrode 70, and the grid-like mesh electrode 72 is arranged to this opening 71. And an electron lens which is led to a semiconductor device 80, without completing most electrons emitted from the photoelectric surface 22 with an effective diameter of 8mm can consist of shortening the cathode electrode 18. If furthermore specified, it will assume that the electron tube 100 is used in the strong field of 2T (tesla) extent in the direction of a tube-axial line passing through the core of a case 90.

[0026] All over such a strong magnetic field, since an electronic travelling direction will be decided with the sense of a field, electric field can be used only for accelerating an electron. That is, it becomes impossible to form the electron lens by electric field, and the effective diameter of the substantial photoelectric surface 22 will be restricted by electronic plane-of-incidence 84a (R> drawing 6 6 reference) of the opening 71 of the anode electrode 70, or the semiconductor device 80 mentioned later. Then, in order to secure the effective diameter of the big photoelectric surface 22 as much as possible, both the semiconductor devices 80 that have the anode electrode 70 which has the big opening 71, and big electronic plane-of-incidence 84a are needed. Such a service condition is demanded in the high energy experiment which used the accelerator.
[0027] Moreover, the middle flanges 15a and 15b were inserted in the insulating case 90 for mitigating the instability by electrification of a case 90, and -8kV - 4kV which distributed equally the electrical potential difference of -12kV to the photoelectric surface 22 to the middle flanges 15a and 15b is impressed.
[0028] As shown in drawing 4 and drawing 5 , the grid-like mesh electrode 72 is arranged and such a mesh electrode 72 is made by the opening 71 of the anode electrode 70 by etching partially the anode electrode 70 made from stainless steel. In this case, the line breadth of the mesh electrode 72 is 50 microns, and a pitch is 1.5mm. An electron penetrates only the part of the numerical aperture (93%) of such a mesh electrode 72.
[0029] It is because opening 71 of the anode electrode 70 was enlarged according to electronic plane-of-incidence 84a of a semiconductor device 80 as a reason for having formed the mesh electrode 72 in the opening 71 of the anode electrode 70. That is, when opening 71 of the anode electrode 70 is enlarged, it is for the effectiveness of making feedback of the cation which the trough of the potential of minus by the side of the photoelectric surface 22 sank in from opening, and was generated in electronic plane-of-incidence 84a of a semiconductor device 80 controlling to decrease. Then, since it can prevent that the potential of the minus from the photoelectric surface 22 invades into the electronic plane-of-incidence 84 side if the mesh electrode 72 is added, the feedback repression effectiveness of ion is maintainable. In addition, the overall diameter of the opening 71 of the anode electrode 70 is smaller than electronic plane-of-incidence 84a of PD80.
[0030] As shown in drawing 6 , the semiconductor device 80 which is PD uses as a substrate ingredient the diffusion wafer which made high concentration diffuse deeply Lynn which is the impurity of n mold from the rear face of a high resistance n mold wafer, and has n mold channel stop layer 83 which carried out the ion implantation of Lynn to high concentration, and formed it in the circumference part of the front face of the high resistance n mold substrate 82 with which the rear face became n mold high concentration contact layer 81. Moreover, disc-like p mold plane-of-incidence layer (breakdown voltage control layer) 84 which diffused and formed boron in high concentration is formed in the central part of the front face of a substrate 82, and the front face of the channel stop layer 83 is established in the wrap oxide film 85 and ****** 86 by the circumference part of the plane-of-incidence layer 84. Furthermore, the plane-of-incidence electrode 87 of the aluminum film which contacts this and supplies an electrical potential difference to the plane-of-incidence layer 84 is formed in the plane-of-incidence layer 84, and the antistatic electrode 88 of the aluminum film in contact with the channel stop layer 83 is formed in the plane-of-incidence electrode 87 and the estranged location. Substantially, electronic plane-of-incidence 84a of this PD80 is prescribed by the bore of the plane-of-incidence electrode 87.
[0031] Then, if -12kV of photoelectric surfaces of such the electron tube 100 is impressed [22] and OV is impressed to the anode electrode 70, since the contact layers 81 of a semiconductor device 80 are the anode electrode 70 and this potential, OV will be given, and, as for electronic plane-of-incidence 84a, -50V will be given through the penetration pin 32, a wire 33, and the plane-of-incidence electrode 87. Here, the actuation to the incident light of this electron tube 100 is the same as that of the 1st operation gestalt. And by arranging the mesh electrode 72 to opening 71, even if it enlarges opening 71 of the anode electrode 70, ion feedback can be controlled appropriately. Namely, when opening 71 of the anode electrode 70 is enlarged, and the mesh electrode 72 exists Since stain **** of the electric field which advance into the electronic plane-of-incidence 84a side exceeding the opening 71 of the anode electrode 70 with which the trough of the low voltage from the photoelectric surface 22 by which bias was carried out to minus was grounded can be controlled It can control effectively that the gas molecule ionized by electronic plane-of-incidence 84a by electronic incidence returns to the photoelectric surface 22 or a case 90 exceeding opening 71.
[0032] The light-receiving side of the input face-plate 21 is large, and operates stably over a long period of time in a high field, and the photoelectric tube 100 of the 2nd operation gestalt mentioned above is used in the high energy experiment using an accelerator.
[0033]
[Effect of the Invention] Since the electron tube by this invention is constituted as mentioned above, it

acquires the following effectiveness.
[0034] That is, the opening area of opening of an anode electrode is formed smaller than the plane-of-incidence product of the electronic plane of incidence of a semiconductor device, and the electron tube with which a semiconductor device enables actuation in which the conductivity type covered at the long period of time by connecting the substrate of n mold to a stem electrically, making an anode electrode and a stem into this potential, and impressing a reverse bias to a semiconductor device while the electronic plane of incidence and the conductivity type of p mold have the substrate of n mold, and it was stabilized becomes possible.

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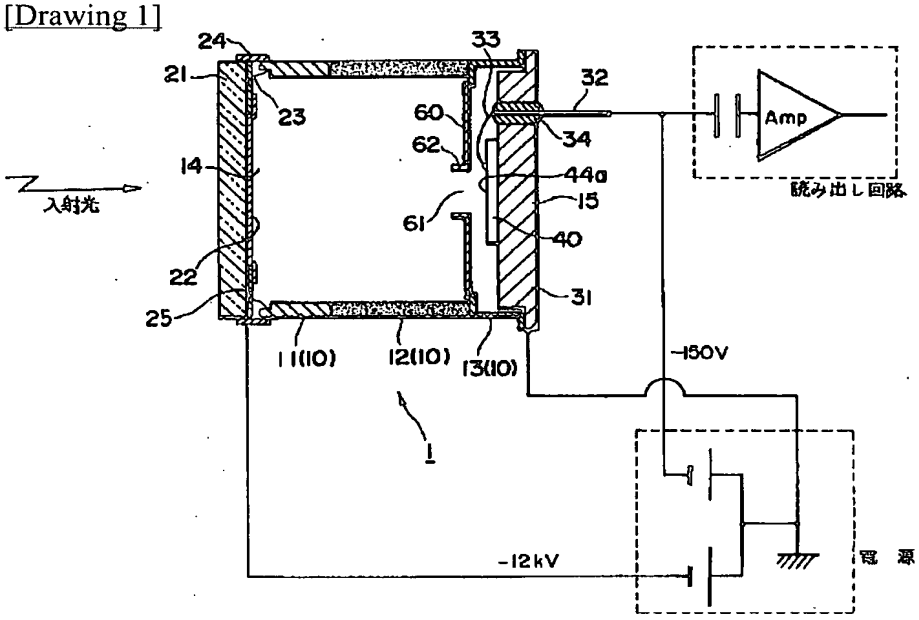
DRAWINGS

[Drawing 1]



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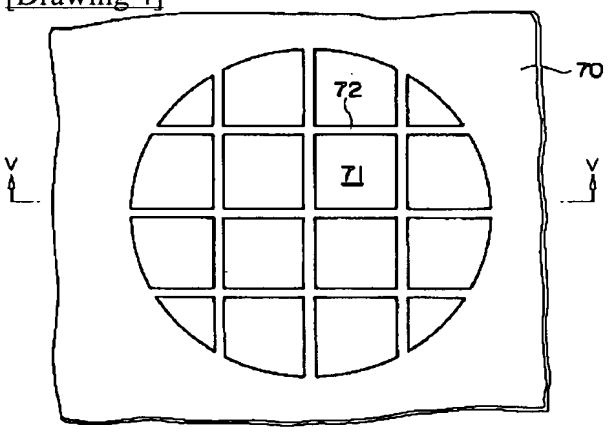
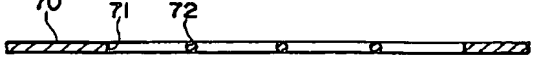
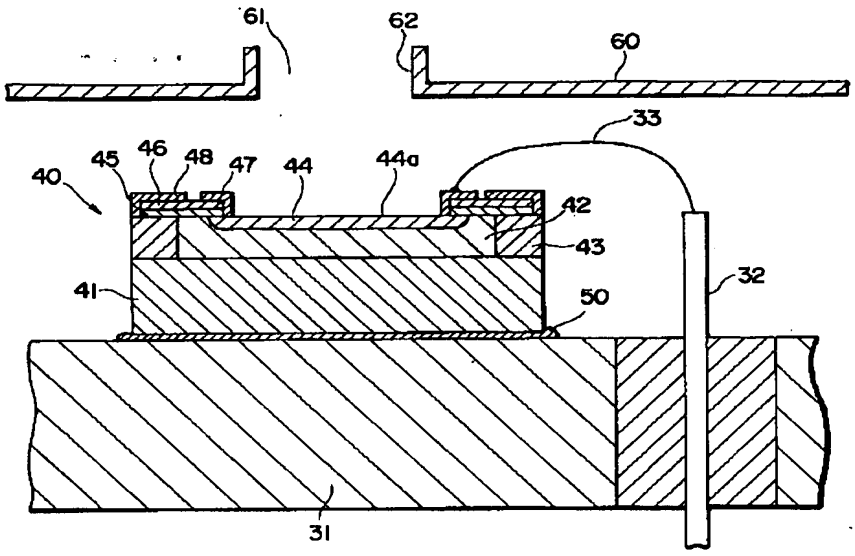


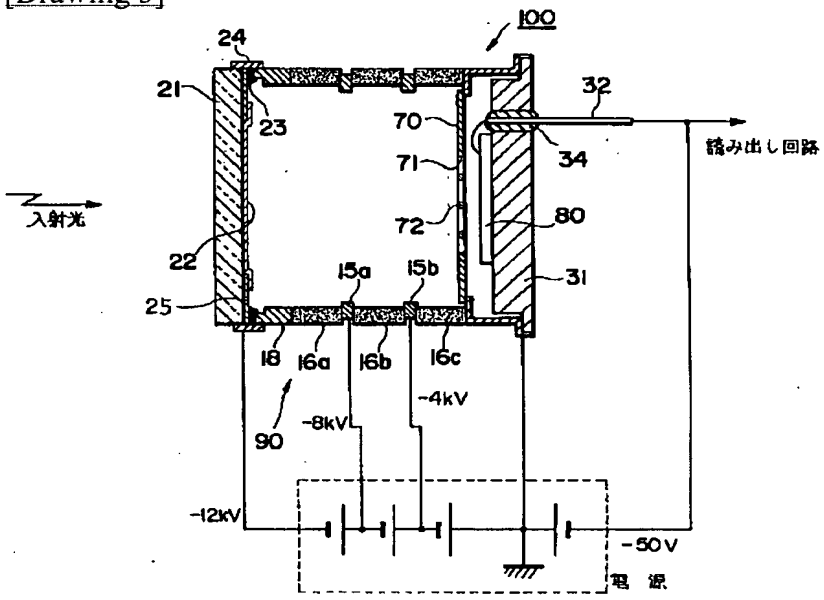
[Drawing 5]



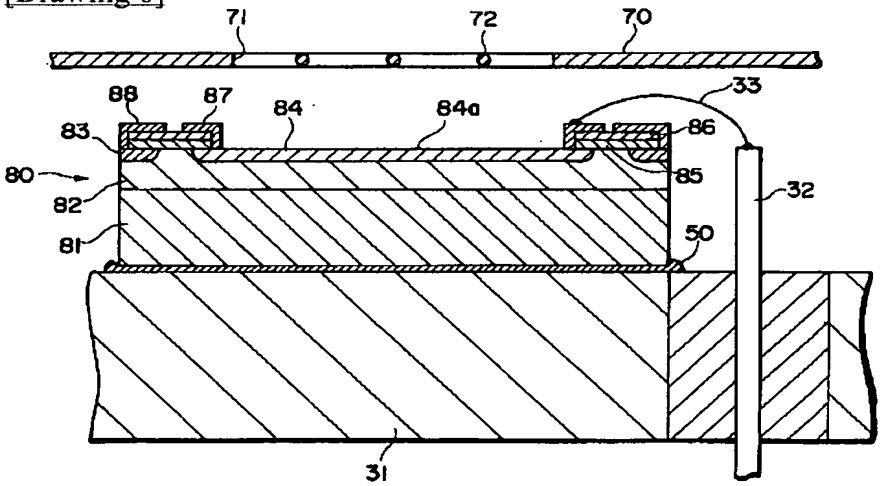
[Drawing 2]



[Drawing 3]



[Drawing 6]



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